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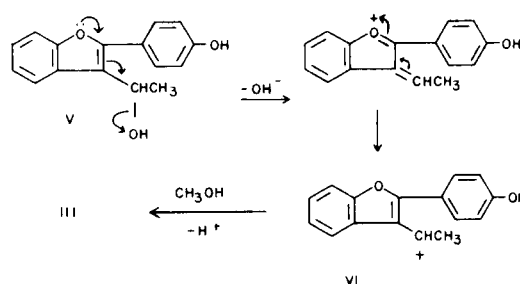
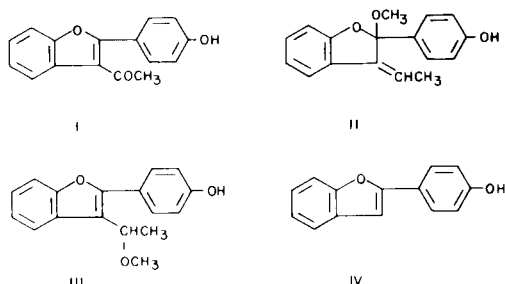
Solvolysis in Sodium Borohydride Reduction of 3-Acetyl-2-phenylbenzofurans

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During an investigation of anthocyanidin oxidation products (1) attempts were made to reduce a number of 3-acetyl-2-phenylbenzofurans to the corresponding secondary alcohols by means of sodium borohydride in methanol. Unexpectedly it was found that a methoxyl group is introduced into the reduction products. Reduction of 3-acetyl-2-(4-hydroxyphenyl)benzofuran (I) in methanol, for example, gives an almost quantitative yield of a crystalline monomethoxyphenol, $C_{17}H_{16}O_3$. This is unstable in aqueous acids and is largely converted into the corresponding ethoxy compound when treated with ethanol and a trace of mineral acid. Thus, of a number of possible structures for the reduction product, the ketal structure (II) appeared probable. UV and IR spectra, however, clearly revealed the presence of an intact benzofuran nucleus and indicated the alternate structure III for this compound.

The IR spectrum (Nujol) of the reduction product has strong peaks at 6.2μ (conjugated $C=C$) and 7.86μ ($C=O$). The unsubstituted benzofuran (IV) (2) has similar peaks at 6.2μ and 7.94μ . In ethanol the reduction product has λ_{max} 298 $m\mu$ ($\log \epsilon$ 4.31) and a pronounced inflection at 241 $m\mu$. On addition of sodium ethylate the λ_{max} undergoes a bathochromic shift of 23 $m\mu$ to 321 $m\mu$ ($\log \epsilon$ 4.40). The benzofuran IV, λ_{max} (EtOH) 309 $m\mu$ ($\log \epsilon$ 4.44), inflection at 247 $m\mu$, also undergoes a bathochromic shift of 23 $m\mu$ to give λ_{max} 332 $m\mu$ ($\log \epsilon$ 4.49) in the presence of sodium ethylate. On the basis of these spectral comparisons it follows that the reduction product is the 3-substituted benzofuran. The lower λ_{max} of III compared to that of IV would be expected from the electron donating character of the 3-alkyl substituent.

The reaction of 3-acetyl-2-phenylbenzofurans with sodium borohydride and methanol may be interpreted as (a) normal reduction of the carbonyl to secondary alcohol V, (b) electron donation from the furano oxygen leading to expulsion of OH^- and formation of the carbonium ion VI, and (c) methanolysis of VI to give III.



EXPERIMENTAL

Reduction of 2-(4-hydroxyphenyl)-3-acetylbenzofuran in methanol.

Sodium borohydride (0.77 g., 4 mol. equivs.) was added in portions during 5 min. to a suspension of 2-(4-hydroxyphenyl)-3-acetylbenzofuran (1) (1.26 g.) in methanol (20.0 ml.). The mixture became warm and all of the solid passed into solution. After 5 min. it was cooled and slowly acidified with 10% aqueous hydrochloric acid (20 ml.), whereupon colorless, glistening crystals separated. Excess of water was added and the product was collected (1.1 g.) and recrystallized from methanol. Compound III separated as colorless needles, m.p. 190°.

Anal. Calcd. for $C_{17}H_{16}O_3$: C, 76.1; H, 6.01; MeO-, 11.5. Found: C, 76.0; H, 5.97; MeO-, 11.9.

The acetate of the reduction product, prepared by heating with acetic anhydride and sodium acetate for one min., crystallized from methanol as colorless, felted needles, m.p. 119°, λ_{max} (EtOH) 293 $m\mu$.

Anal. Calcd. for $C_{19}H_{18}O_4$: C, 73.5; H, 5.85; CH_3CO- , 13.9. Found: C, 73.5; H, 5.87; CH_3CO- , 13.6.

The methyl ether of the reduction product was prepared by reaction with methyl iodide and potassium carbonate in acetone in the usual way. It crystallized from Skellysolve F as colorless flakes, m.p. 74-75°, λ_{max} (EtOH) 298 $m\mu$ ($\log \epsilon$ 4.36). This methyl ether was also obtained directly by sodium borohydride reduction of 2-(4-methoxyphenyl)-3-acetylbenzofuran in methanol.

Anal. Calcd. for $C_{18}H_{18}O_3$: C, 76.6; H, 6.43; MeO-, 22.0. Found: C, 76.7; H, 6.54; MeO-, 22.3.

Reduction of 2-(4-methoxyphenyl)-3-acetyl-7-methoxybenzofuran (1.48 g.) with sodium borohydride (0.77 g.) in methanol (40 ml.) similarly gave a colorless trimethoxy compound (0.90 g.). This crystallized from methanol as colorless, glistening flakes, m.p. 81°, λ_{max} (EtOH) 290, 246 $m\mu$.

Anal. Calcd. for $C_{19}H_{20}O_4$: C, 73.1; H, 6.45. Found: C, 73.0; H, 6.57.

Reduction of 2-(4-methoxyphenyl)-3-acetyl-6-methoxybenzofuran under analogous conditions gave a trimethoxy product which separated from methanol as colorless needles, m.p. 82°, λ_{max} (EtOH) 309 $m\mu$.

Anal. Calcd. for $C_{19}H_{20}O_4$: C, 73.1; H, 6.45. Found: C, 73.0; H, 6.47.

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